Pacific Lamprey

2017 Regional Implementation Plan

for the

Lower Columbia/Willamette

Regional Management Unit

Willamette Sub-Unit

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I. Status and Distribution of Pacific Lamprey in the RMU

A. General Description of the RMU

Willamette River Sub-Unit

The Willamette Sub-Unit of the Lower Columbia River/Willamette Regional Management Unit is comprised of twelve 4th field HUCs that are situated within three Environmental Protection Agency (EPA) Level III Ecoregions: Coast Range, Willamette Valley and Cascades (http://www.epa.gov/wed/pages/ecoregions/level_iii.htm; Figure 1, Table 1).

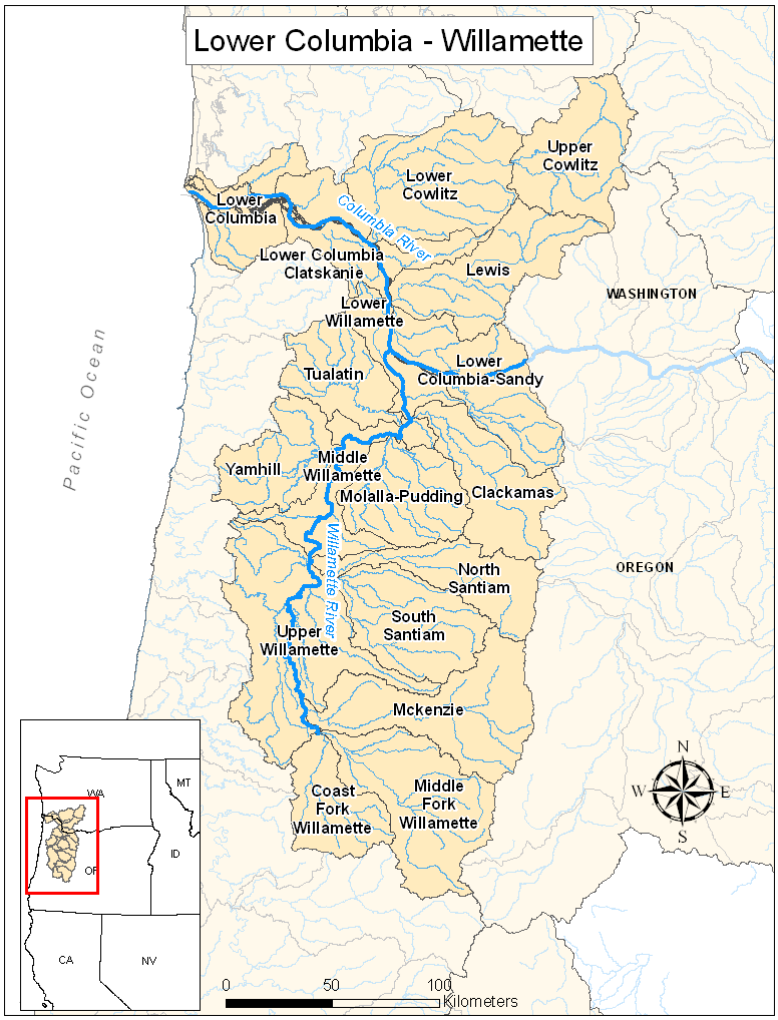

Figure 1. Map of watersheds within the Lower Columbia River/Willamette Regional Management Unit.

Table 1. Drainage Size and Level III Ecoregions of the 4th Field Hydrologic Unit Code (HUC) Watersheds located within the Willamette Sub-Unit.

Watershed	HUC Number	Drainage Size (km2)	Level III Ecoregion(s)
Middle Fork	17090001	3,540	Willamette Valley
Coast Fork Willamette	17090002	1,726	Coast Range
Upper Willamette	17090003	4,850	Willamette Valley
McKenzie	17090004	3,468	Willamette Valley, Cascades
North Santiam	17090005	1,979	Willamette Valley, Cascades
South Santiam	17090006	2,696	Willamette Valley, Cascades
Middle Willamette	17090007	1,841	Willamette Valley
Yamhill	17090008	1,999	Coast Range
Molalla-Pudding	17090009	2,267	Willamette Valley, Cascades
Tualatin	17090010	1,836	Coast Range, Willamette Valley
Clackamas	17090011	2,442	Willamette Valley, Cascades
Lower Willamette	17090012	1,668	Willamette Valley

B. Status of Species

Conservation Assessment and New Updates

Increased attention on Pacific lamprey has increased our understanding of this species in the Willamette Basin. Monitoring efforts, in which lamprey are either the target species or information is collected during other species' monitoring, have expanded the amount of information available and the quality of this information.

Previous studies have suggested a lack of genetic population structure (e.g., Goodman et al. 2008; Spice et al. 2012). However, these studies have focused on large geographical areas and have not controlled for time. Recently, two independent studies on adult Pacific Lamprey, conducted in different years and utilizing different genetic tools have reported evidence for some genetic differentiation among a relatively small body size, early migrating run, and a larger, later migrating run of adult Pacific Lamprey at Willamette Falls (Hess et al. 2015; Clemens et al. 2017a). Moderate genetic differentiation of adult Pacific Lamprey also occurred across years in the Willamette River Basin (Clemens et al. 2017a).

Abundance, Distribution and Connectivity

Since 2010, the Confederated Tribes of Warm Springs Reservation of Oregon have collected information to estimate the abundance of Pacific lamprey adults at Willamette Falls (Falls) and the number passing the Falls through the fishways. Average estimates for this six year period are 182,224 adults (abundance at the Falls) and 65,446 adults (passing above the Falls; Table 2). Population estimates for tributaries to the Willamette are largely not available. While some counts exist at Leaburg Dam on the McKenzie River and the Upper and Lower Bennet Dams on the North Santiam, these facilities are not yet equipped to accurately or consistently document lamprey passage.

Historical occupancy of Pacific lamprey was extensive throughout the Lower Columbia/Willamette RMU. From the previous threats assessment, Luzier et al. (2011) estimated that the current distribution was reduced 50-70% from historical ranges. Pacific

lamprey are currently thought to occupy 1,998 km of stream (~3,057 km^2 of the watershed) in the Willamette Sub-Unit (Table 3). Current distribution of lamprey in the Willamette Sub-Unit is strongly related to physical migration barriers. Twenty large dams are present within the Willamette Sub-Unit; 13 are owned and operated by the U.S. Army Corps of Engineers' (Corps or USACE) and collectively referred to as the Willamette Valley Project; at this time, none have successful upstream lamprey passage. Other large dams are for either non-federal hydropower production or water supply. See "Passage" for more discussion on dam passage.

Of the estimated 371 dams present in the Willamette Basin, approximately 148 are privately owned and used primarily for the purposes of irrigation. The greatest concentration of dams can be found in the Tualatin (82) and Yamhill (65) watersheds (Hulse et al. 2002). Culverts are also widespread throughout the watersheds of the Willamette Sub-Region and impact Pacific lamprey distribution to an unknown extent.

Recent information collected during the 2017 Threats Assessment and Regional Implementation Plan meetings will be used to determine the percentage of historical distribution still currently occupied. The steelhead intrinsic potential historical distribution, once available, will be used to estimate for Pacific lamprey historical distribution (USFWS information expected in Fall 2017).

Table 2. Estimated Pacific lamprey adult abundance, and numbers passing Willamette Falls and Bonneville Dam, 2010-2015, percent of total that were harvested, percent of total numbers that passed Willamette Falls (Baker and McVay 2015, 2016; Baker 2016).

Year	Total Abundance At Willamette Falls	Percent Harvested	Numbers Passing Willamette Falls Fishway	Percentage Passing
2010	64,388	2.5%	27,043	42%
2011	107,383	4.0%	46,819	44%
2012	243,048	2.7%	111,559	46%
2013	173,821	4.3%	49,365	28%
2014	336,305	1.1%	125,778	37%
2015	168,398	1.3%	32,112	19%
Average	**182,224**	**2.7%**	**65,446**	**36%**

Table 3. Current Distribution of Pacific Lamprey by Stream Length and Watershed Area for each 4th Field Hydrologic Unit Code (HUC) Watershed located within the Willamette Sub-Unit. Historical Distribution will be calculated by Steelhead Intrinsic Potential to determine the percent of historical habitat occupied later in 2017.

Watershed HUC	Current Distribution Length (km)	Current Distribution Area (km2)	Historical Distribution (km2)	Percent Occupied (%)
Middle Fork	25	41	TBD	TBD
Coast Fork Willamette	67	114	TBD	TBD
Upper Willamette	352	544	TBD	TBD
McKenzie	100	165	TBD	TBD
North Santiam	73	116	TBD	TBD
South Santiam	205	332	TBD	TBD
Middle Willamette	142	251	TBD	TBD
Yamhill	179	260	TBD	TBD
Molalla-Pudding	169	225	TBD	TBD
Tualatin	218	297	TBD	TBD
Clackamas	190	316	TBD	TBD
Lower Willamette	278	396	TBD	TBD
Overall	**1,998**	**3,057**		

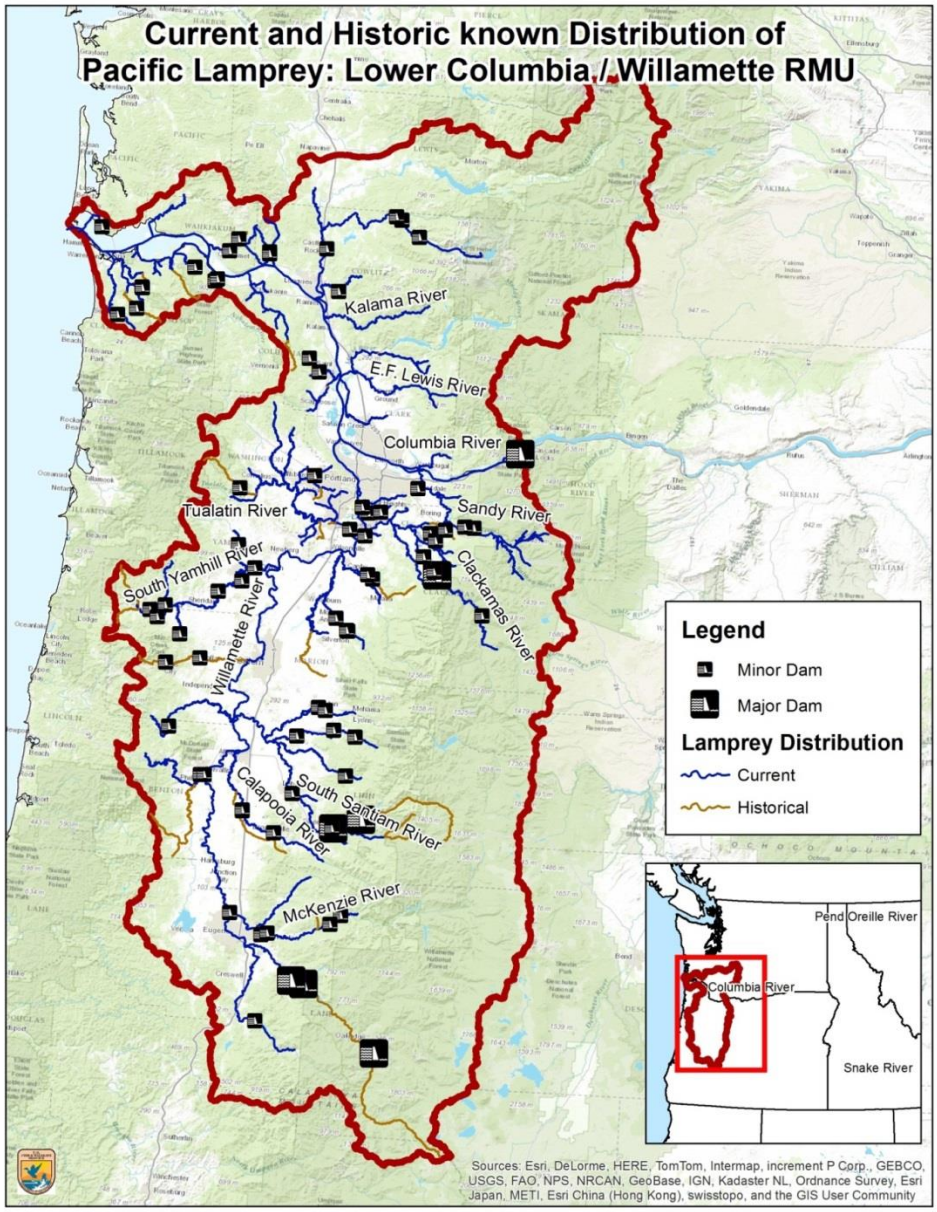

Figure 2. Estimated current and historical distribution for Pacific Lamprey: Lower Columbia and Willamette Regional Management Unit (USFWS Data Clearinghouse 2016).

C. Threats

Summary of Major Threats

The key threats within the Willamette Sub-Unit were identified by RMU participants during the Risk Assessment revision meeting in February 2017 (Table 4). Key threats are defined as those threats in which the average scope and severity across all HUCs was greater than 2.5 on a scale from 1- 4 (>3.5 = High,2.5- 3.49 =Moderate, 1.5- 2.49=Low and <1.5= Insignificant; U=Unknown). Stream and floodplain degradation (non-dam), water quality (non-dam) and dam-related flow alterations[1] are the highest priority threats in the Willamette Sub-Unit, followed by dam-related stream and floodplain degradation and dam-related passage. (Table 4). The "dam-related" threats refer to those threats primarily caused by large dams, which affect multiple parameters (passage, water quality, seasonal baseflows and flood flows (timing, magnitude and duration), floodplain dynamics, habitat (e.g. inundation of habitat, loss of coarse sediment supply), and species composition (e.g. habitat suitability, predator/prey dynamics) This distinction was made to better identify the cause of the threats, and ensure some threats were not masked by the presence of these dams.

Stream and Floodplain Degradation.—Nearly 70 percent of Oregon's population resides in and around the Willamette Basin. Human settlement and development has greatly altered the physical habitat and hydrology of the Sub-Unit. In upland areas, forestry is the predominant land use. Fire suppression and historical and ongoing timber harvest practices have altered the diversity and age/size composition of riparian vegetation and trees. Many watersheds in the Willamette Sub-Unit are lacking mature conifers that play a pivotal role in bank stability, water quality protection, thermal cover, and the provision of large woody debris. In the valley, extensive agriculture and urban development have reduced the quality and complexity of aquatic and riparian habitats. Efforts to reduce flooding (dikes, levees, riprap, dams) and improve navigation (dredging, large wood clearing), have straightened and scoured streambeds, eliminated side channels and cut off flood plains. Cultivation, riparian clearing and conversion of land for crops, pastures, vineyards and development have filled and/or drained wetlands, increased soil erosion and sedimentation, and promoted the establishment and spread of invasive plant species. Simplification of the river channel and flow regulation and simplification of the mainstem Willamette have been hypothesized to be a cause of the decreased numbers of adult Pacific Lamprey harvested by Tribal members at Willamette Falls (Clemens et al. 2017b).

Water Quality.—Elevated water temperature, low dissolved oxygen, bacteria, and toxic pollutants such as herbicides, pesticides, heavy metals and flame retardants, are some of the primary water quality concerns in the Willamette Sub-Unit. These threats may be attributable to a number of human related causes including riparian clearing, water withdrawals, failing septic systems, sewer overflow, and urban and agricultural run-off. Toxins may be particularly harmful to Pacific lamprey because larvae burrow and feed in mud and fine substrates where toxins accumulate (Nilsen et al. 2015; Clemens et al. 2017b). Monitoring efforts to improve and protect water quality for fish, wildlife, and human health are ongoing in the Willamette Sub-Unit.

[1] "Flow Alterations" were formerly referred to as "Dewatering and Flow Management" in Luzier et al. (2011).

A combination of laboratory and field tests and field observations suggest that warm summertime temperatures (greater than or equal to 20^{o}C) during July-August can result in several biological end points that may prevent adult Pacific lamprey from surviving, reproducing, or migrating far up into the Willamette Basin (Clemens et al. 2016). First, summertime temperatures correlated with a large die-off of adult Pacific Lamprey at Willamette Falls , and these temperatures have correlated with skewed sex ratios (more males) in one year at Willamette Falls (Clemens et al. 2016). Second, summertime temperatures correlated with documented testicular atresia (damaged testes) in males, which may affect their ability to subsequently mature and spawn (Clemens et al. 2016). Third, exposure of adult Pacific lamprey to summertime temperatures can result in faster maturation (Clemens et al. 2009). Summertime stream temperatures correlate with slowing and in some cases, ceasing of upstream migration (Clemens et al. 2012a, 2017), which may result in lamprey not spawning as far up into the Willamette Basin (Clemens et al. 2016). Conversely, higher annual flow discharges correlate with farther migration upstream (Clemens et al. 2016, 2017). In summary, this evidence suggests that warm summertime temperatures may thwart penetration into the upper basin with successful reproduction in a few ways.

Flow Alterations – (formerly "Dewatering and Flow Management"). —Flow alterations was ranked as a Moderate key threat. Low flow conditions occur naturally in many watersheds of the Willamette Sub-Unit during summer months. These conditions may be aggravated by water withdrawals for municipal, industrial, commercial and agricultural use. In several tributaries, the large storage dams offset and augment seasonal low flows in much of the Willamette Basin, and some negatively impact natural temperature and flow regimes. Water releases from thermally stratified reservoirs generally result in cooler water temperatures downstream of the dam in summer and warmer water temperatures in fall and winter. Abnormal seasonal temperature fluctuations may impact the behavior, development, and fitness of adult and juvenile lamprey to an unknown extent. In 2005, the USACE completed a water temperature control tower at Cougar Dam on the South Fork McKenzie River, which has alleviated much of the dam-induced seasonal abnormalities in the McKenzie River. Such temperature control structures are still needed elsewhere in the Willamette Basin to return to more normative seasonal temperature regimes (e.g. North Santiam River, the Middle Fork Willamette).

Water diversions and impoundments alter the quantity and timing of flow events, which may impact adult and juvenile lamprey migration cues, decrease spawning habitat availability, prevent access to backwater or side channel habitats, create low water barriers, and contribute to mortality if incubating eggs or burrowing larvae are dewatered or exposed to a high temperature or low oxygen environment (Clemens et al. 2017b). Some improvements to flow regimes have occurred in the Willamette Basin. Since 2002, the USACE has largely operated their Willamette Valley Project dams according to minimum flows and ramping rates that were formalized under the Willamette Project Biological Opinion issued by the National Marine Fisheries Service (NMFS 2008) for the protection of anadromous salmonids. Further, through the Willamette Valley Sustainable River Project, The Nature Conservancy and the USACE and numerous other agencies and organizations are working to ensure that Willamette River flows are managed to benefit fish and wildlife habitats as well as local communities (https://www.nature.org/ourinitiatives/regions/northamerica/unitedstates/oregon/placesweprotect/wv-fact-sheet.pdf?redirect=https-301).

Table 4. Summary of the assessment results for the main threats of the Willamette Sub-Unit. Key Threats are those that rank Moderate or High (2.5 or greater). Threats ranked less than 2.5 are not listed.

Watershed	Dam-Related Passage		Dam-Related Flow Alterations		Dam-Related Stream & Floodplain Degradation		Dam-Related Water Quality		Dam-Related Predation	
	Scope	Severity	Scope	Severity	Scope	Severity	Scope	Severity	Scope	Severity
Willamette Sub-Unit										
Middle Fork Willamette	4	4	4	4	4	4	4	4	3	3
Coast Fork Willamette	4	4	4	4	4	4	4	4	2.5	2.5
Upper Willamette	2	4	4	4	3	4	3	4	2	4
McKenzie	3	3	3	3	3	3	3	3	2	2
North Santiam	4	4	4	4	4	4	3	3	1	1
South Santiam	4	4	4	4	4	4	4	4	2	4
Middle Willamette	2	4	4	4	4	4	3	3	1	U
Yamhill	2	2	2.5	2.5	2	2	2.5	2.5	1	1
Molalla-Pudding	2.5	2.5	2.5	2.5	2	2	2.5	2.5	3	3
Tualatin	2.5	2.5	2	2	2	2	2	2	3	3
Clackamas	3	3	1	2	1	1	1	1	3	U
Lower Willamette	1	2	3	3	4	4	4	4	4	4
Average Scope/Severity	2.8	3.3	3.2	3.3	3.1	3.2	3.0	3.1	2.3	2.8
Rank	**M**	**M**	**M**	**M**	**M**	**M**	**M**	**M**	**L**	**M**
Mean	3.0		3.2		3.1		3.0		2.5	
Overall Threat Rank	**M**		**M**		**M**		**M**		**M**	

Table 4 (continued). Summary of the assessment results for the main threats of the Willamette Sub-Unit. Key Threats are those that rank Moderate or High (2.5 or greater). Threats ranked less than 2.5 are not listed.

Watershed	Flow Alterations (non-dam)		Stream & Floodplain Degradation (non-dam)		Water Quality (non-dam)		Predation (non-dam)	
	Scope	Severity	Scope	Severity	Scope	Severity	Scope	Severity
Willamette Sub-Unit								
Middle Fork Willamette	1	1	3.5	3	2	2	1	1
Coast Fork Willamette	3	2.5	2.5	2.5	3	3	2.5	2.5
Upper Willamette	3.5	3	4	3.5	4	3.5	1.5	U
McKenzie	2	2	3	3	2	1	1	1
North Santiam	3	3	2.5	3	2	3	1.5	3
South Santiam	3.5	3	3	3	3	3	1	U
Middle Willamette	3.5	3	4	4	3.5	4	4	U
Yamhill	3	3	4	4	4	4	3	3
Molalla-Pudding	4	4	4	4	4	4	3	3
Tualatin	2.5	2.5	4	4	4	4	3	3
Clackamas	1	2	3	3	3	3	3	U
Lower Willamette	2.5	2.5	4	4	4	4	4	4
Average Scope/Severity	2.7	2.6	3.5	3.4	3.2	3.2	2.4	2.6
Rank	**M**	**M**	**H**	**M**	**M**	**M**	**L**	**M**
Mean	2.7		3.4		3.2		2.5	
Overall Threat Rank	**M**		**M**		**M**		**M**	

Passage- As previously stated, the current distribution of Pacific lamprey is largely determined by the many large dams throughout the Willamette Basin that do not provide passage (Clemens et al. 2012b; Schultz et al. 2014; Table 5). The USACE Willamette Valley Project dams were primarily built to reduce flood risks, but also generate electricity and provide water storage for irrigation, recreation and drinking water. The structures range in size from 49 feet (Fern Ridge) to 519 feet (Cougar) tall and provide little or no fish passage for Pacific lamprey. Largely constructed in the early 1960s, the USACE dams block hundreds of miles of historical, anadromous spawning and rearing habitat and have adversely affected native fish populations in the basin. Consequently, the Willamette Valley Project Biological Opinion, issued by the National Marine Fisheries Service (NMFS 2008), requires the Corps to improve adult and juvenile salmonid passage at several high priority dams.

USACE's adult fish trap and haul facilities located at the base of these dams are primarily designed for anadromous salmonids, which are trapped and transported by truck and released upstream of the dams. Some of the recent upgrades include features (e.g. rounded walls at fishway entrances and orifices) that may increase the ability to capture and haul adult lamprey if additional infrastructure (such as ramps and collection boxes) was added. Work to date has included the construction or upgrade of adult fish collection facilities at Cougar, Detroit (Minto), Foster, Dexter and Fall Creek Dams to improve trap and haul conditions for salmonids (i.e., improved attractant flows, larger holding areas, less direct handling of fish). At this time, Fall Creek Dam has the only experimental ramps for upstream lamprey passage at these USACE dams.

Downstream fish passage solutions for salmonids at the USACE dams are still under evaluation. No permanent downstream fish passage collection facilities for any of the USACE dams have been completed. Juvenile fish (all species) must pass through turbines, spillway gates, or other routes of water passage as they migrate downstream. USACE has tested a small, experimental, floating surface collector at Cougar Dam for downstream passage of salmonids. Other studies to determine downstream passage solutions at Detroit and Lookout Point Dams continue. It is unclear if passage improvement measures will ultimately restore access to the habitat above these dams for Pacific lamprey.

Although most passage projects in the Willamette Sub-Unit are focused on improving conditions for ESA-threatened spring Chinook salmon and winter steelhead, a growing number of projects are providing passage for Pacific lamprey. In conjunction with Federal Energy Regulatory Commission relicensing, Portland General Electric (PGE) has installed three lamprey passage structures at Willamette Falls Hydroelectric Project (Lower Willamette River), rebuilt the existing fish ladder at River Mill Dam (Clackamas River) and made modifications to the fishway that traverses the Faraday and North Fork Dams (Clackamas River) to improve upstream passage of adult Pacific lamprey. PGE is also monitoring the downstream migration of juvenile lamprey with two, new surface collectors at River Mill and North Fork Dams. These facilities are collecting and enumerating lamprey outmigrants. The collection efficiency of the downstream passage structures are unknown, but thousands of ammocoetes and macropthalmia have been collected each year since construction. PGE is also translocating adult Pacific lamprey into the Clackamas above North Fork Dam to increase larval production (and the pheromones they produce) in the upper basin in efforts to increase adult attraction to this area. In the future, PGE will perform a multi-year radio telemetry study that will assess migration and passage success of adult Pacific lamprey through the fish ladder at North Fork Dam.

Table 5. Passage conditions at most large dams located in the Willamette Sub-Unit.

Dam / ***Ownership***	**River**	**Passage Conditions for Pacific Lamprey**
Dexter, Lookout Point, and Hills Creek *USACE*	Middle Fork Willamette	A trap and haul facility for anadromous salmonids occurs below Dexter Dam, the lower-most dam on the Middle Fork Willamette. Future upgrades may increase the ability to capture and haul adult lamprey upstream of these dams. Permanent downstream passage facilities are not present.
Fall Creek Dam *USACE*	Tributary to Middle Fork Willamette below Dexter Dam	A trap and haul facility for anadromous salmonids occurs below Fall Creek Dam, and USACE has installed a ramp/collection box specific for lamprey. Future upgrades may increase the ability to capture and haul adult lamprey upstream of these dams. CTGR are conducting a reintroduction/translocation of adults captured at Willamette Falls above this dam. Downstream passage facilities are not present; "passage" for downstream migrant salmonids is provided by annual 1-2 week drawdown of the reservoir- typically in December or January each year.
Dorena Dam *USACE*	Row River- Tributary to Coast Fork	No fish passage facilities are present or planned at this dam.
Cottage Grove Dam *USACE*	Coast Fork Willamette River	No fish passage facilities are present or planned at this dam.
Fern Ridge Dam *USACE*	Long Tom River	No fish passage facilities are present or planned at this dam.
Leaburg Dam *EWEB*	McKenzie River	Two upstream fishways are located at Leaburg Dam (~10 feet tall). Lamprey passage efficiency is unknown, but Pacific lamprey are found above this dam. EWEB's diversions are screened to NMFS criteria, which are adequate for larger outmigrants, but may allow the smallest larvae to pass through the screen, and intermediate sized larvae may become impinged or wedged in the gaps of the screen material.
Cougar Dam *USACE*	South Fork McKenzie River	A trap and haul facility for anadromous salmonids occurs below Cougar Dam; recent upgrades may increase the ability to capture and haul adult lamprey upstream if additional infrastructure was added. Permanent downstream passage facilities are not present; USACE is testing a small, pilot facility for downstream passage of salmonids.
Blue River Dam *USACE*	Blue River (tributary to McKenzie River)	No fish passage facilities are present or planned at this dam.

Table 5 continued.

Dam / ***Ownership***	**River**	**Passage Conditions for Pacific Lamprey**
Trail Bridge Dam *EWEB*	McKenzie River	No fish passage facilities are present at this dam. Future upgrades in the next ~5 years will include a trap and haul facility that includes design considerations for trap and haul of adult Pacific lamprey. Downstream passage will be provided by spill and powerhouse shut-down, which will occur year-round.
Mino, Big Cliff and Detroit Dams *USACE*	North Santiam	A trap and haul facility for anadromous salmonids occurs below Big Cliff Dam, the lower-most dam, at Minto. Recent upgrades may increase the ability to capture and haul adult lamprey upstream if additional infrastructure was added. Permanent downstream passage facilities are not present.
Foster and Green Peter Dams *USACE*	South Santiam	A trap and haul facility for anadromous salmonids occurs below Foster Dam, the lower-most dam. Recent upgrades may increase the ability to capture and haul adult lamprey upstream if additional infrastructure was added. Permanent downstream passage facilities are not present.
Scoggins Dam *BLM*	Tualatin River	No fish passage facilities are present or planned at this dam.
River Mill, Faraday, and North Fork Dams *PGE*	Clackamas River	A new fishway at the lower-most River Mill Dam was constructed in 2006 and provides 90% passage efficiency for Pacific lamprey. PGE has recently modified the North Fork Fishway, which traverses both Faraday and North Fork dams, and is currently evaluating passage here. Permanent downstream passage facilities, which are collecting and enumerating lamprey outmigrants, are at North Fork and River Mill dams. The collection efficiency is unknown, but thousands of ammocoetes and macropthalmia have been collected each year since construction.
Willamette Falls Dam *PGE*	Willamette River	Modifications to the existing fishway to improve lamprey passage have been completed. Additionally, seasonal lamprey ramps are installed annually to provide upstream egress for lamprey upstream passage. Modifications to improve downstream salmonid passage have been completed, including improved spill conditions, which are likely to improve passage conditions for lamprey somewhat.

Predation. Predation (both dam-related and not dam-related) was ranked as a moderate threat to lamprey. Predation on lamprey likely occurs throughout the Willamette Basin: sea lion and white sturgeon activity is commonly seen immediately below Willamette Falls, and many warm-water predatory fish species are common throughout the basin in the large reservoirs and lower tributaries of the Willamette. These non-native fish are able to overwinter and survive in the basin largely because of large reservoirs or other modified habitats. At this time, there is very little direct study of predation in the Willamette Basin; thus, while there may be many potential

predators of lamprey present, in many areas it is uncertain what the severity of such predation is to the lamprey population.

Other.—Predicted trends in human population growth, increased development, and anticipated effects of climate change (i.e., elevated water temperatures, increased demand for consumptive surface water use, altered flow regimes) will likely compound existing threats to Pacific lamprey throughout the Willamette Sub-Unit.

Restoration Actions

The following work was recently completed or is actively occurring in the Willamette Sub-Unit. Additional detail is provided in the Willamette Sub-Unit Meeting Notes for the Pacific Lamprey Threats Assessment and RIP meeting (USFWS 2017).

- Clackamas Watershed
    - Two new surface collectors for downstream fish passage have been completed by PGE at the River Mill and North Fork Dams over the past few years. Both are collecting juvenile lamprey outmigrants.
    - PGE will begin Trap and Haul efforts to transfer adult lamprey above North Fork Dam in 2017, and continuing through 2025.
    - Multiple habitat restoration efforts have occurred in the Clackamas Basin (PGE, Metro and others), including the ongoing "Shade Our Streams" efforts by the Clackamas River Basin Council and PGE.
- Fall Creek (Middle Fork Willamette)
    - The Confederated Tribes of the Grand Ronde is leading a multi-year lamprey translocation study on Fall Creek (2012- present).
    - The USACE is evaluating adult collection facilities at Fall Creek Dam, including lamprey specific ramps. The upgrades to the existing Fall Creek Adult Salmonid Collection Facility (2017-2018) will also include lamprey-friendly features that may ultimately assist with a trap and haul program for Pacific lamprey at this dam.
- The Confederated Tribes of Warm Springs Reservation of Oregon continues to assess passage and abundance of adult Pacific lamprey at Willamette Falls.
- Middle Fork Willamette
    - The existing Mill Pond at the Springfield Millrace was removed, thus improving lamprey access. Additional habitat improvements at this site planned for 2017 will increase habitat diversity and improve habitat for lamprey (City of Springfield and many other partners).
- Ongoing distribution and occupancy sampling. Information collected through these surveys will guide conservation actions throughout the Willamette Sub-Unit.

II. Selection of Priority Actions

A. Prioritization Process

The highest priority threat in the Willamette Sub-Unit is stream and floodplain degradation (score = 3.4). Several other factors ranked above 3.0 : dam-related passage, dam-related flow alteration and water quality. Priority projects identified by participating members of the Willamette Sub-Unit RMU addressed threats to passage, stream and floodplain degradation and uncertainties in Pacific Lamprey distribution and enumeration.

B. High Priority Proposed Project Information

PROJECT: Improving counts of Pacific Lamprey in the McKenzie River (Leaburg Dam)

Project Lead Contact: Katherine Nordholm (ODFW)

Threat addressed by project: Lack of information on the Status of Pacific lamprey

Project Description:

This project addresses the deficiency of information on the status of Pacific lamprey in the McKenzie River Basin. Currently, reliable estimates of population abundance or population trends are lacking. Having unknown population parameters is common throughout Pacific lamprey distribution and most population and trend estimates are bases on counts from Willamette Falls.

Video cameras in Leaburg Dam's fish ladders have recorded fish passage since 1993. Pacific lamprey are observed in these videos however the counts do not completely capture the Pacific lamprey population. Lamprey have been observed passing over the fish ladder without being captured on video. Thus, the counts of Pacific lamprey at Leaburg Dam cannot be used for population estimates or population trend monitoring. In addition, Pacific lamprey may be able to pass upstream of the dam through the auxiliary water supplies for the fish ladders or other routes where water is flowing over smooth surfaces.

The objective of this project is to develop the methodology to provide an accurate annual count of Pacific lamprey passing Leaburg Dam. With infrastructure already in place at Leaburg Dam, there is an opportunity to start a long-term Pacific lamprey population monitoring project. Upgrading the video equipment in both fish ladders at Leaburg Dam will allow a complete count of Pacific lamprey passing over the ladders. Additionally, a telemetry study will be conducted to determine the potential for Pacific lamprey to navigate upstream of the dam without using the fish ladders.

HUC 5 *Location*: McKenzie River, Oregon (#17090004)

Facilities ownership: Eugene Water and Electric Board (EWEB)

Rationale and linkage to the watershed:

Long term dam counts of fish passing over Leaburg Dam are not an accurate record of the total number of Pacific lamprey that pass over the fish ladder. Upgrading the video monitoring equipment in the Leaburg Dam fish ladder will allow complete counts of passing Pacific lamprey. The addition of a telemetry study will determine if Pacific lamprey are able to navigate upstream of Leaburg Dam without passing through the fish ladders.

Expected outcome (threats addressed):

Upgrade the video equipment at Leaburg Dam to accurately monitor population abundance and trends over time. Begin building a long-term data set on Pacific lamprey migration in the McKenzie River.

Identification and coordination with relevant stake holders:

ODFW, EWEB, USACE, Tribal interests

Feasibility and expected timeframes:

Feasibility is high. Project planning and implementation could start immediately.

Proponent Role and Responsibilities:

Install additional video cameras in the Leaburg Dam fish ladders. Fund a position to enumerate fish caught passing the fish ladder. Trap lamprey at the base of Leaburg dam. Tag lamprey with RFID PIT tags, and tag a subset with radio telemetry tags. Fund a position for tracking the telemetry tagged fish and for monitoring and evaluating PIT tag project.

Budget and identification of potential funding source:

ODFW, EWEB, USACE, USFS. Estimated costs can very; a more detailed breakdown of cost can be provided later.

Camera equipment and setup: $7,500

Personnel: Four to eight months: $12,000 to $24,000

Telemetry Equipment: $8,000 - $20,000

Total: $27,500 to $51,500

PROJECT: Estimate N_e Above North Fork Dam on the Clackamas River

Project Lead Contact: Nick Ackerman (PGE)

Threat addressed by project: Small Effective Population Size

Project Description: Estimate N_e Above North Fork Dam on the Clackamas River:

Our objective is to determine the effective population size (N_e) of Pacific lamprey above North Fork Dam on the Clackamas River. This will be accomplished through genetic sampling of juvenile Pacific lamprey collected at Portland General Electric's (PGE) downstream migrant sampling facility in 2017. Our estimate of N_e will be representative of adults from brood years 2009 – 2014.

HUC 5 *Location*: Clackamas: 17090011

Facilities ownership: Portland General Electric

Rationale and linkage to the watershed:

Historically, passage at North Fork Dam has been assumed to be poor (Ackerman et al. 2016). From 2017-2025 PGE will be conducting a trap-and-haul program to improve Pacific lamprey passage around North Fork Dam (Ackerman 2017). The intent of the program is to haul approximately 250 adults per year from River Mill Dam to upstream of North Fork Dam. However, it is unknown how this number compares to the current adult abundance upstream of

the dam. Until 2013 there was no means for trapping or counting Pacific Lamprey on the North Fork Ladder, and even after 2013 a newly installed lamprey trap was proven to be ineffective as it was found that lamprey were able to successfully bypass the trap (Ackerman et al. 2016). Therefore, while passage rates through the ladder have been low, an unknown number of lamprey have annually passed through the ladder into the upper basin. A better understanding of the pre trap-and-haul program N_e upstream of North Fork Dam may help refine the trap and haul program and provide valuable baseline information in assessing the effectiveness of the program.

Expected outcome (threats addressed):

Estimate recent effective population size of Pacific lamprey in the upper Clackamas Basin prior to implementation of a significant trap-and-haul program.

Identification and coordination with relevant stake holders:

PGE, Quantitative Consultants, Inc., and Columbia River Inter-Tribal fish Commission (CRITFC)

Feasibility and expected timeframes:

Feasibility is high. Genetic samples will be collected from macropthalmia in the winter of 2017/2018. Genetic analysis will be run in early 2018 with reporting complete by summer of 2018.

Proponent Role and Responsibilities:

Nick Ackerman of PGE will be the main proponent of the project. PGE will collect the genetic samples and provide them to the CRITFC genetics laboratory in Hagerman, ID for genotyping. Estimates of N_e will be made by Quantitative Consultants, Inc., using sibship-based estimators (reviewed in Ackerman et al. 2016b).

Budget and identification of potential funding source:

We estimate the project budget (including the genotyping of 500 juvenile lamprey samples, data analysis, and a project report) to cost $40,000.

PGE will provide $10,000 of the $40,000 project cost and the labor to collect the samples for the project at no cost. PGE operates and maintains the juvenile sampling facilities used for the evaluation at no cost to the project. An itemized budget is available upon request.

PROJECT: Lower South Fork McKenzie River Floodplain Enhancement Project

Project Lead Contact: Kate Meyer (USFS)

Threat addressed by project: Stream & Floodplain Degradation and Water Quality

Project Description: Current large-scale project underway to restore floodplain connectivity and function on over 500 acres of historical alluvial delta at the confluence of the South Fork McKenzie River. Project will remove approx. 40 acres of levees and augment sediment (over 200,000 cubic yards) and large wood (3,000-4,000 pieces) on 4.5 miles of the South Fork below Cougar Dam, resulting in 5-10 miles of secondary channel reconnection (up to 400% increase). This project will dramatically improve spawning and rearing habitat for Pacific lamprey.
HUC 5 *Location*: South Fork McKenzie River Watershed HUC #1709000403, McKenzie River

Subbasin

Facilities ownership: Willamette National Forest, US Army Corps of Engineers

Rationale and linkage to the watershed:

Efforts to prevent flooding (dikes, levees, riprap, dams) and improve navigation (dredging, large wood clearing), have straightened and scoured streambeds, eliminated side channels and cut off floodplains throughout the McKenzie River subbasin and Willamette Basin. Pacific lamprey rely on low gradient, depositional floodplains with abundant fines and gravels and channel complexity for spawning and rearing. Pacific lamprey were positively identified in the project area in 2015.

Expected outcome (threats addressed):
Project would improve the physical, chemical, and biological processes that support a healthy, resilient ecosystem and sustain habitat conditions needed to improve productivity for spring Chinook salmon, bull trout, Pacific lamprey, rainbow trout, cutthroat trout, and other native species. It would specifically improve spawning and rearing habitat for Pacific lamprey that is easily accessible below impassable dams. Project will also help improve water quality and mitigate effects of climate change by: (1) storing more water in the reconnected floodplain and slowly releasing it throughout the year, making more water available during low flow periods; (2) keeping water cooler through increased hyporheic exchange through the floodplain and through augmented sediment; and (3) allowing floodplains to naturally clean and filter water.

Identification and coordination with relevant stake holders:

USFS, McKenzie Watershed Council, USACE, ODFW, NMFS, USFWS, Eugene Water & Electric Board, Outfitters and Guides

Feasibility and expected timeframes:

This is one of the highest priority projects for the Willamette NF. An 80% design has been completed and NEPA will be conducted in 2017. Implementation will begin in 2018 if funding can be secured.

Proponent Role and Responsibilities:
Project is co-managed by McKenzie Watershed Council and Willamette National Forest

Budget and identification of potential funding source:
Potential funding sources include: USFS, EWEB, USACE, BPA, OWEB, USFWS, Drinking Water Provider Partnership, National Fish and Wildlife Foundation, Trout Unlimited; total cost is ~$4 million.

2017 Activities and Specific Requests for Funding

- USFS staff salary for design, planning, NEPA, permitting, grant writing, communication/outreach has all been covered with internal funding and a grant from the Drinking Water Providers Partnership. Funding for collecting local plants and seed and growing them out at a nursery has also covered by grants.

- The McKenzie Watershed Council, who is co-managing this project, is **seeking funds for planning, outreach/communication, and partnership development - $5,000-$10,000.**

- **PRE- PROJECT MONITORING:** We are seeking additional funding (either through the Watershed Council or USFS) for pre-project monitoring, which will likely include:
    - purchase and installation of piezometers to measure change in water table - **$5,000-$10,000**
    - data collection along floodplain transects to measure wetted area, substrate diversity, habitat patch complexity, vegetation, etc. - **$5,000-$10,000**
    - geomorphic change detection using LiDAR or Structure from Motion Aerial Photography - **$10,000-$20,000**
    - pre-project low elevation aerial imagery - **$5,000-$10,000**
    - fish abundance (including lamprey) and biomass estimates using eDNA - **$5,000-$20,000** (costs are uncertain – we're trying to track down better estimates)

2018 Activities: Implementation of Phase I – lower 2.0 miles/400 acres of floodplain; Total cost = approx. $1 million; project could utilize any funding amount.

III. References

Ackerman, N.K. 2017. Study Plan Proposed Modification: Evaluation of Adult Pacific Lamprey Upstream Passage Effectiveness Through the Clackamas River Hydroelectric Project. Clackamas River Project. FERC No. 2195. Prepared by Portland General Electric.

Ackerman, N.K., M.M. David, and B. Pyper. 2016a. Evaluation of Adult Pacific Lamprey Upstream Passage Effectiveness through the Clackmas River Hydroelectric Project, 2015/2016 Progress Report.

Ackerman, M.W., B.K. Hand, R.K. Waples, G. Luikart, R.S. Waples, C.A. Steele, B.A. Garner, J. McCane, and M.R. Campbell. 2016b. Effective number of breeders from sibship reconstruction: empirical evaluations using hatchery steelhead. Evolutionary Applications. doi: 10.1111/eva.12433.

Baker, C. 2016. Synthesis of Pacific lamprey studies conducted by the Confederated Tribes of the Warm Springs Reservation of Oregon, 2003 to 2013. Confederated Tribes of Warm Springs Reservation of Oregon, Warm Springs, Oregon. 235 pp.

Baker, C. and C. McVay. 2015. Willamette Falls Lamprey Study, 2014 Annual report to BPA, project number 2008-308-00. Confederated Tribes of Warm Springs Reservation of Oregon, Warm Springs, Oregon. 27 pp.

Baker, C. and C. McVay. 2016. Willamette Falls Lamprey Study, 2015 Annual report to BPA, project number 2008-308-00. Confederated Tribes of Warm Springs Reservation of Oregon, Warm Springs, Oregon. 31 pp.

Clemens, B. J., M. G. Mesa, R. J. Magie, D. A. Young, and C. B. Schreck. 2012b. Pre-spawning migration of adult Pacific lamprey, Entosphenus tridentatus, in the Willamette River, Oregon (USA). Environmental Biology of Fishes. 93: 245 – 254.

Clemens, B. J., L. Wyss, R. McCoun, L. Schwabe, I. Courter, S. Duery, J. Vaughn, and C. B. Schreck. 2012a. Migration characteristics and habitat use of the imperiled adult Pacific lamprey in the Willamette Basin: Prelude to estimating requirements for persistence. Final Draft Report to the Columbia River Inter-Tribal Fish Commission. April 2012. 51 pp.

Clemens, B., C. Schreck, S. van de Wetering, and S. Sower. 2016. The potential roles of river environments in selecting for stream- and ocean-maturing Pacific Lamprey, Entosphenus tridentatus (Gairdner, 1836). pp. 299 – 322. In: A. Orlov, & R. J. Beamish (eds.) Jawless Fishes of the World. Cambridge Scholars.

Clemens, B. J., S. van de Wetering, J. Kaufman, R. Holt, and C. B. Schreck. 2009. Do summertime temperatures trigger springtime maturation in adult Pacific lamprey, Entosphenus tridentatus? Ecology of Freshwater Fish. 18: 418 – 426.

Clemens, B. J., and 21 co-authors. 2017b. Conservation challenges and research needs for Pacific Lamprey in the Columbia River Basin. Fisheries. 42: 268-280.

Clemens, B. J., L. Wyss, R. McCoun, I. Courter, L. Schwabe, C. Peery, C. B. Schreck, E. K. Spice, and M. F. Docker. 2017a. Temporal genetic population structure and interannual variation in migration behavior of Pacific Lamprey Entosphenus tridentatus. Hydrobiologia. 794: 223-240.

Goodman, D. H., S. B. Reid, M. F. Docker, G. R. Haas, and A. P. Kinziger. 2008. Mitochondrial DNA evidence for high levels of gene flow among populations of a widely distributed anadromous lamprey *Entosphenus tridentatus* (Petromyzontidae). Journal of Fish Biology. 72: 400-417.

Hess, J. E., N. R. Campbell, M. F. Docker, C. Baker, A. Jackson, R. Lampman, and S. R. Narum. 2015. Use of genotyping by sequencing data to develop a high-throughput and multifunctional SNP panel for conservation applications in Pacific Lamprey. Molecular Ecology Resources. 15: 187-202.

Hulse, D., S. Gregory, and J. Patterson Baker. (EDS). (2002) Willamette River Basin Planning Atlas: Trajectories of Environmental and Ecological Change. (2nd edition), Oregon State University Press, Corvallis, Oregon 97333. 180p.

Luzier, C.W., H.A. Schaller, J.K. Brostrom, C. Cook-Tabor, D.H. Goodman, R.D. Nelle, K. Ostrand and B. Streif. 2011. Pacific Lamprey (Entosphenus tridentatus): Assessment and Template for Conservation Measures. U.S. Fish and Wildlife Service, Portland, Oregon. 282 pp. http://www.fws.gov/columbiariver/publications.html

NMFS. 2008. 2008-2023 Willamette River Basin Project Biological Opinion. NOAA's National Marine Fisheries Service, Northwest Region, Seattle WA. F/NWR/2000/02117.

Schultz, L., M.P. Mayfield, G.T. Sheoships, L.A. Wyss, B.J. Clemens, B. Chasco, and C.B. Schreck. 2014. The Distribution and Relative Abundance of Spawning and Larval Pacific Lamprey in the Willamette River Basin. Final Report to the Columbia Inter-Tribal Fish Commission for project years 2011-2014. CRITFC Contract number C13-1. BPA Contract number 60877. BPA Project number 2008-524-00.

Spice, E. K., D. H. Goodman, S. B. Reid, and M. F. Docker. 2012. Neither philopatric nor panmictic: microsatellite and mtDNA evidence suggest lack of natal homing but limits to dispersal in Pacific Lamprey. Molecular Ecology. 21: 2916-2930.

USFWS. 2017. Meeting Notes: Willamette Sub-Unit RMU- Pacific lamprey Threats Assessment and Regional Implementation Plan, February 15 and 16. U.S. Fish and Wildlife Service, Vancouver, Washington & Portland, Oregon.